PB-215 117

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June 1969

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Paper No. 69-235

PB 215 117

THE IMPACT OF AGRICULTURAL POLLUTANTS-- ON SUBSEQUENT USERS

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Abstract

Pollutants arising from agricultural activities can have adverse and detrimental effects on the water quality requirements of subsequent users. The major sources and types of pollutants involved are discussed. Their effect and impact on subsequent users are considered. The need for improved management and/or treatment concepts to minimize the effects of the pollutants discharged to receiving waters is discussed. Suggestions are offered regarding agriculture's responsibility in water pollution control activities.

For presentation at the 1969 Annual Meeting
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Purdue University
W Lafayette, Indiana

June 22-25, 1969

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THE IMPACT OF AGRICULTURAL POLLUTANTS-- ON SUBSEQUENT USERS

James P. Law, Jr and Harold Bernard

The Federal water pollution control program began on a small scale in 1948 with the first Federal Water Pollution Control Act which had a five-year expiration date In 1953, it was extended for three years, then, in 1956, the first permanent Federal Water Pollution Control Act (P.L. 84-660) became law The basic act has been amended and strengthened several times: Federal Water Pollution Control Act Amendments of 1961 (P.L. 87-88), Water Quality Act of 1965 (P.L. 89-234), and Clean Water Restoration Act of 1966 (P L 89-753).

One of the key features of the clean water program is the provision of the Water Quality Act of 1965 which called for all States to establish water quality standards for their interstate and coastal waters. The States were required to make crucial decisions regarding the uses of their water resources, the quality of water to support these uses, and specific plans for achieving such levels of quality The purpose of this program is to enhance the quality and value of polluted water and to protect the quality of clean water. The standards are, in effect, the blueprints for an effective clean water program

In order to assist the States in establishing acceptable water quality standards and implementation plans, the Federal Water Pollution Control Administration (FWPCA) set forth guidelines which clearly established that water quality standards should be designed to "enhance the quality of water " They gave support to President Johnson's stated position that "no one has the right to pollute." They further stated that the implementation plan "... should include consideration of all relevant pollutional sources, such as municipal and industrial wastes, cooling water discharges, irrigation return flows, and combined sewer overflows " One of the most controversial policies, and yet one of the most important in achieving its objectives, is that guideline which states:

> "No standard will be approved which allows any wastes amenable to treatment or control to be discharged into any interstate water without treatment or control

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> regardless of the water quality criteria and water use or uses adopted. Further, no standard will be approved which does not require all wastes, prior to discharge into any interstate water, to receive the best practicable treatment or control unless it can be demonstrated that a lesser degree of treatment or control will provide for water quality enhancement commensurate with proposed present and future water uses."

The significance of this policy statement is that almost universally the standards and implementation plans which have been approved call for secondary treatment of municipal wastes and equivalent levels of treatment for industrial wastes (1).* Even so, this is but a single step of a long journey ahead.

Agricultural Pollutants--Sources and Types

Wastes arising from man's activities that affect the quality of water come mainly from municipal, industrial, mining, marine, and agricultural sources. Although the major effort appears to be in the treatment and control of municipal and industrial wastes, agriculture is by no means exempt from the war on pollution. The major sources of pollution associated with agricultural activities are animal wastes, irrigation return flows, fertilizers, and biocides. The types of pollutants arising from these sources can be characterized briefly.

Animal Wastes - The rapid growth of large animal-feeding operations has resulted in a tremendous increase in the potential pollution hazard from animal wastes. A recent report (2) states: "Animal wastes in this country probably exceed wastes from any other segment of our agricultural-industrial-commercial-domestic complex." The Department of Agriculture (3) has estimated that over 1.5 billion tons of animal wastes are produced annually, one-third of which is liquid, and as much as 50 percent coming from concentrated production operations (Table 1). From the population equivalent values given, it is apparent that a feedlot operation with 10,000 cattle will produce wastes equivalent to a city of 164,000 people. A city of this size will use over 8 million gallons of water per day to carry its wastes while the feedlot never uses water in this amount. Untreated municipal sewage may have a biochemical oxygen demand (BOD) of about 100

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*Numbers in parenthesis refer to references cited.

Table 1. Wastes Produced by Livestock[1/]

	U. S. Population 1965	Total Solid Waste	Total Liquid Waste	Population Equivalent
	Millions	Million tons/yr.	Million tons/yr.	Per animal
Cattle	107	1,004.0	390.0	16.4
Horses	3	17.5	4.4	11.3
Hogs	53	57.3	33.9	1.9
Sheep	26	11.8	7.1	2.45
Poultry	490	48.0	--	0.14
Total		1,138.6	435.4	

1/Adapted from Wadleigh (Ref. 3).

to 400 mg/l. Runoff from cattle feedlots produced by rainfall is a very high strength organic waste and may have a BOD content as high as 10,000 mg/l (3, 4) depending on rainfall amount and intensity, antecedent moisture conditions, slope and surface conditions of lot, degree of deterioration of wastes, and other factors. It has been further demonstrated that feedlot runoff is a source of high concentrations of bacteria normally considered as indices of sanitary quality (4). Other pollutants arising from animal wastes are the nutrient compounds of nitrogen and phosphorus, and mineral salts.

Irrigation Return Flows - The major pollutional factor associated with irrigation is the increased concentration of soluble mineral constituents in the drainage water (5, 6, 7). It has been estimated that of our total water supply diverted and consumptively used, 90 percent is used in irrigation (3). Because of this high consumptive use through the processes of evapotranspiration, salts present in the irrigation water supply become more concentrated in the drainage effluent. For irrigation agriculture to survive, salts that accumulate in the soil must continually be leached to deeper horizons, ground water, or the drainage system. A favorable salt balance is required, i.e., salt leaving the area by drainage or deep percolation must equal or exceed that received in the water supply.

The total salt burden of many of our western streams may be as much as 40 percent man-caused The two basic causes of salinity increases in streams are the salt concentrating and salt loading effects. The former results from the diversion and consumptive use of water described above in which no additional minerals are discharged, and the total salt burden of the stream remains the same. The salt loading effect results from those activities which contribute additional mineral pollutants. Municipal, industrial, and mining wastes are examples; however, under certain conditions, irrigation return flows may also contribute additional salts. Two cases in point are (a) new irrigated areas where natural salts are present in the soil and (b) deep percolation water that passes through salt-bearing strata on its way to the stream drainage system. It is thus apparent that irrigation return flows may contribute to both the concentrating and loading effects.

Fertilizer Applications - Plant nutrients are those inorganic chemical elements essential for the mineral nutrition of plants. Included are the major fertilizer elements, nitrogen, phosphorus, and potassium; secondary elements, calcium, magnesium, and sulfur; and micronutrients such as iron, manganese, zinc, copper, and boron. Nitrogen and phosphorus are of particular concern in connection with water pollution (2). These nutrients may originate from farm and ranch land, barnyards and feedlots, municipal and rural sewage, and industrial wastes. Here, we are concerned with those nutrients that reach water courses from fertilizer applications on farm land.

Fertilizer nitrogen may be taken up by plant roots, undergo reversible (biological) and irreversible (soil colloids) fixation in the soil, be lost in gaseous form, or be carried below the root zone by percolating soil water (8). Phosphorus, on the other hand, is immobile in soil, and almost none moves downward with percolating water. Repeated applications can build up the level of total phosphorus in the upper soil layer so that it may be carried on eroded soil particles into streams and surface-water systems. The best controls are to avoid overfertilization and reduce watershed and stream bank erosion (2).

Agricultural Biocides - Proper use of pesticides results in great benefits to man and his environment. On the other hand, when misused or used carelessly, they have caused harm. It has been estimated (3) that in 1964 farmers spent over $500 million for agricultural biocides to treat about 83 million acres with insecticides and 97 million acres with herbicidal chemicals. Their widespread use continues to increase (2, 3).

Of all the biocides used to date, the chlorinated hydrocarbon insecticides are the most persistent in nature. Pesticide monitoring programs conducted by Federal and State agencies show that residues of certain insecticides, particularly DDT, are widespread, not only in soils, but also in the tissues of fish, wildlife, birds, and man himself (3). The full significance of these residue levels has not been established. The widespread occurrence of pesticide residues is not limited to the animal kingdom, for they have been found in almost all of our national waterways (9). The Division of Pollution Surveillance of FWPCA conducted surveys for chlorinated hydrocarbon residues in our surface waters in 1964, 1965, and 1966. About 100 sampling stations throughout the nation were involved, ranging from municipal water intake points to the mouths of rivers in tidal waters. Of all the stations sampled, only one on the Columbia River at McNary Dam was free of pesticide all three years. It is significant that 7 of 11 other stations with no pesticides during two of the survey years were also at or just below impoundments. This suggests that sedimentation and other phenomena associated with impoundments are dominant factors in removing chlorinated hydrocarbons from surface waters (9).

Herbicides are next in importance as pollutants occurring in water supplies. Large quantities are used annually to control noxious weeds on cropland and along irrigation canals. Residues in the soil from the treatment of one crop may cause damage to succeeding, susceptible crops. The use of herbicides for aquatic weed control is subject to regulation and restrictions. No organic herbicides are registered for use in potable water supplies, although certain ones are registered for use in water that is to be used for irrigation.

Most herbicides do not injure fish at the concentrations required to control submersed aquatic weeds; however, at higher than the recommended rates of application, they may become toxic to fish, wildlife, livestock, humans, and crops (3).

Fungicides are less persistent but more toxic than many other organic biocides since many of them contain compounds of mercury, sulfur, copper, and nickel. Many of these are restricted from use on fruit and vegetable crops. Treated seed in excess of planting needs may not be fed to poultry and livestock. Cases of poisoning from this source have occurred (3).

Nematocides in use are halogenated hydrocarbons, carbamates, and organophosphates Their residues persist in soil, may be absorbed by plants, and are a potential hazard to man via foodstuffs and animal products. To date, there is no evidence of injury to man or animals from such residues. Nematocides are a potential hazard as water pollutants in runoff from treated fields and irrigation water that has been treated (3).

Water Quality Standards and Criteria

Water quality standards adopted by the States include water use classifications, criteria necessary to support these uses, and a plan for implementation and enforcement. Often, the words "criteria" and "requirement" are used interchangeably. The same can be said for the words "standards" and "objectives." In order to clarify meanings, a standard is a plan established by governmental authority as a program for water pollution control and abatement; and criteria are scientific requirements on which a decision or judgment may be based concerning the suitability of water quality to support a designated use (10). The Federal Water Pollution Control Act authorizes the States to set standards. Quality characteristics of a physical, chemical, or biological nature demanded by municipal, agricultural, industrial, aquatic and wildlife, or other use are requirements or criteria.

A recent report entitled "Water Quality Criteria" (10) is the most comprehensive document on water quality requirements to date. As such, it will serve as a basic reference by groups and agencies engaged in water quality studies and standards setting activities. For the purpose of this paper, the criteria set forth in that report will form the basis for assessing the impact of agricultural pollutants on subsequent beneficial water uses.

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Impact on Public Water Supplies

The highest quality criteria are those set for water destined for municipal and some industrial water supplies. The Public Health Service drinking water standards of 1962 (11) are recognized officially as the adopted criteria for domestic and municipal use. Municipal supplies are often subjected to treatment processes designed to improve the quality. These may include flocculation, sedimentation, and filtration to remove suspended materials; reduction of hardness; and disinfection to improve the bacteriological quality. There are, however, constituents in water that cannot be economically removed by present-day technology. Important among these are the agricultural pollutants, total dissolved solids, nitrates, sulfates, chlorides, and certain biocides. Recently published criteria (10) establish both "permissible" and "desirable" limits on these constituents for public water supplies (Table 2).

Many of our western rivers show the effects of irrigation return flows on the quality of water. Along a 200-mile stretch of the Sevier River in central Utah, there are seven complete stream diversions for irrigation (12). Between the diversions, there are several small, high quality streams entering the valley, yet the salt concentration shows a 20-fold increase over the 200-mile area to a value greater than 900 mg/l. A similar 21-fold increase in dissolved solids concentration is reported in the Colorado River from its Grand Lake inlet (38 mg/l) to Imperial Dam (809 mg/l) (13) Man's activities in the upper Colorado River basin account for a rise in salinity of nearly 240 mg/l to about 500 mg/l at Lee's Ferry in Arizona (14) The Department of the Interior (15) reports that 32% of the total salt load at Hoover Dam comes from irrigation sources and only about 1% from municipal and industrial sources. The remaining two-thirds comes from natural sources.

The Rio Grande is another classic example of the effect of irrigation on the mineral content of a stream (5, 6). Several reservoirs and diversions for irrigation exist in the 450-mile stretch between Otowi Bridge near Santa Fe and Fort Quitman, Texas. The results of a 20-year study show the mean annual discharge of the river decreases from over one million acre-feet at Otowi Bridge to about 200,000 acre-feet at Fort Quitman. This is mainly due to consumptive use by irrigation. The dissolved solids concentration increases from about 200 mg/l to almost 2,000 mg/l, while the total salt load in the river is almost doubled. These effects are almost totally attributed to irrigation use of the water.

These few cases serve to illustrate the effect of irrigation on the salinity of surface waters. In each case, it will be noted that the resultant downstream salinity is far in excess of the criteria

Table 2. Water Quality Criteria for Public Water Supplies[1/]

Constituent[2/]	Permissible Criteria (mg/l)	Desirable Criteria (mg/l)
Chloride	250	<25
Nitrate (as N)	10	Virtually absent
Sulfate	250	<50
Total Dissolved Solids	500	<200
Insecticides:		
Aldrin	0.017	Absent
Chlordane	0.003	Absent
DDT	0.042	Absent
Dieldrin	0.017	Absent
Endrin	0.001	Absent
Heptachlor	0.018	Absent
Lindane	0.056	Absent
Organic Phosphates	0.1	Absent
Toxaphene	0.005	Absent
Herbicides:		
2,4-D plus 2,4,5-T, plus 2,4,5-TP	0.1	Absent

1/Adapted from Ref. 10.

2/Conventional treatment processes have little effect on these constituents.

established for public water supplies (Table 2). This alone would render these waters unsuitable for such use.

Nitrate-nitrogen is another agricultural pollutant that seriously affects the water quality requirements of public water supplies. The permissible limit has been set at 10 mg/l as N (10, 11). Recent studies revealed that large percentages of applied nitrogen were lost in tile drainage effluent from irrigated silty clay loam soils in the San Joaquin Valley of California (16). The amount of nutrients lost in the discharge was related to the amount applied. The weighted mean concentration from four tile systems was 25 mg/l as N. Although phosphorus losses were insignificant (0.08 mg/l P) compared to N, there were sufficient nutrients (both N and P) in the effluents to cause significant algae growth in the downstream ditches. A survey of fertilizer nutrients in water supplies of Missouri (17) indicated little evidence that fertilizers are a major source of nutrients in water supplies; however, under certain conditions of high rates of fertilizer applications and irrigation on permeable soils, nitrates do move with percolating water and may be found in ground water.

Animal wastes are apparently more serious contributors of nutrient materials to water supplies. Miner et al. (4) studied rainfall runoff from concrete and nonsurfaced feedlots and found total Kjeldahl nitrogen concentrations ranging from 94 to 1,000 mg/l from the concrete lot and from 54 to 540 mg/l from the nonsurfaced lot. Nitrate and nitrite-nitrogen were found in very low concentrations from both lots. This was attributed to prevailing anaerobic conditions in both the runoff and moist litter. Under conditions favorable for nitrification, nitrate-nitrogen may be present in the runoff at concentrations up to 10 mg/l. Total phosphorus ranged from 20 to 80 mg/l as PO_4 from the concrete lot and from 15-45 mg/l as PO_4 from the nonsurfaced lot. Chlorides, as well as other soluble mineral constituents, were found to be quite variable but sufficiently low in concentration that they are not generally a serious feedlot problem. Stewart et al. (18) sampled ground water under feedlots, irrigated and nonirrigated fields in the South Platte River Valley in Colorado. They found the nitrogen content generally much higher under feedlots than under adjacent irrigated fields. Similar differences were observed in organic carbon concentrations, which were 5 to 10 times greater under feedlots.

The fact that chlorinated hydrocarbon insecticide residues have been found in almost all of our national waterways (9) becomes significant when we view the very low permissible limits for public water supplies (Table 2). These limits are in the parts per billion range (1 to 100), and the desirable criterion is "absent." While water concentrations of these insecticides are typically found only in the parts per trillion range, there is still reason for concern that desirable species may be destroyed, eliminated, or impaired

as a result of the effects of these residues in the environment (19). The long-range effect of their accumulation in the food-chain leading to man cannot be fully understood nor precisely predicted at the present.

Industrial water quality requirements are as varied as industries themselves. The leather tanning industry and those that process food and kindred products require water equal in quality to that of public water supplies (Table 2) Others, such as textile, lumber, pulp and paper, chemical, petroleum, and primary metals can tolerate water lower in quality in some constituents. For example, the petroleum industry can use water with mineral dissolved solids up to 3,500 mg/l in some processes, and certain cooling water operations can tolerate brackish water up to 35,000 mg/l dissolved solids (10). The effect of agricultural pollutants on some industrial water supplies is, therefore, not as critical as it is for public water supplies.

Impact on Fish, Other Aquatic Life, and Wildlife

Any use that alters the physical or chemical quality of water will have an impact on the biota that have developed and adapted to the environment. This impact may be beneficial or detrimental and will be the result of all the various factors involved. All of the agricultural pollutants considered thus far can be potential hazards to fish, aquatic, and wildlife.

Fish and aquatic life depend entirely upon the aquatic environment for both their oxygen and food supply. The accepted criteria for warm-water biota (10) state that the dissolved oxygen (DO) concentration should be above 5 mg/l and, for cold-water biota, the DO concentration must not fall below 7 mg/l. Small fluctuations below these values for short periods of time may do no harm, provided the water quality is favorable in all other respects. The release of animal wastes or stormwater runoff therefrom poses a serious threat to the critical DO requirements of all aquatic life. Numerous cases of fish kills caused by such oxygen-demanding wastes are reported (4). In addition, animal wastes are a major source of plant nutrients in surface waters. Enrichment that is not excessive can increase fish production by increasing the growth of microscopic algae and phytoplankton which is a basic element in the aquatic food chain; however, when excessive amounts of plant nutrients are present, nuisance growths of algae and other aquatic vegetation may occur. Once this happens, the die-off and decay of algae masses can lead to oxygen deficiencies and harm to fish and other aquatic life. These considerations stress the importance of a proper nutrient balance for the propagation of fish and other aquatic life.

Small amounts of soluble mineral salts (less than 1,000 mg/1) have little or no effect on fish, aquatic and wildlife. Slightly saline water (1,000 to 3,000 mg/1) has very little effect on wildlife, although 3,000 mg/1 water may cause salt poisoning in pheasant chicks (20). Moderately saline water (3,000 to 10,000 mg/1) becomes unpalatable to most upland game species. Bass, bluegill, and other game fish can live and grow in the lower half of this range even though they cannot spawn successfully in it. Catfish, carp, and certain other scavenger fish can tolerate salinity to the upper limit of this salinity range. Waterfowl can readily use water of this salinity range and higher. Many plants on which they feed can tolerate a wide range of salinity from fresh water to above sea water strength (20). From the above, we conclude that salinity from irrigation water use poses no serious threat to aquatic and wildlife.

More serious problems are encountered when we consider the presence of pesticide residues in the aquatic environment. Endrin, one of the chlorinated hydrocarbon insecticides, is acutely toxic to many fish at about one part per billion or less (19) and has been responsible for many fish kills. Dieldrin is the most persistent of this group of insecticides and the one found most frequently in the major river basins (9). Endrin and DDT were second and third in frequency of detection. Toxaphene proved fatal to rainbow trout at a concentration of one part per billion (19). Aside from the more direct acute effects of pesticide contamination in the aquatic environment, there are the insiduous indirect effects from the biological accumulation of these toxic materials in fish and wildlife. Sublethal concentrations have affected the reproduction of various species. Research proved that female lake trout in New York State concentrated enough DDT in their eggs to kill the fry after absorption of the yolk sac by the fry (21). DDT has been found in the oil of ocean fish at concentrations of 1 to 300 mg/1. DDT and other chlorinated hydrocarbons have been found in rainwater in both the United States and England (19). Cases such as these are ample cause for alarm. There is no alternative to the conclusion that, as far as these organic biocides are concerned, any at all in the aquatic environment creates a potential hazard.

Impact on Aesthetic and Recreation Use

Pollution-laden water, whether it is a stream or lake, is not a "thing of beauty." In 1965, President Johnson called for intensified action to clean up "waterways that were once sources of pleasure, beauty, and recreation," but now are "objectionable to sight and smell" as well as "dangerous for human contact (10)." These statements reflect the growing concern of all Americans about aesthetic and recreational quality of the physical environment. Aesthetically pleasing waters add to the quality of human experience. Water may be

pleasant to look upon, and it may provide a variety of recreational activities. The appearance of pollution reduces both aesthetic and recreational value.

Recommended criteria for aesthetic purposes (10) state that "all surface waters should contribute to the support of life forms of aesthetic value." This recommendation recognizes the significance of fish, waterfowl, wildlife, and other aquatic life to human aesthetic satisfaction. Specific criteria established for fish, other aquatic life, and wildlife (10) provide guidance for water management and protection programs to preserve aesthetic value. The "Guidelines for Establishing Water Quality Standards for Interstate Waters" issued by the Department of the Interior in 1966 (10) provided that "water quality standards should be designed to enhance the quality of water" and "in no case will standards providing for less than existing water quality be acceptable." It follows, then, that aesthetic values may be best realized by continuing efforts toward enhancement of water quality for all uses.

Recreation uses of water have historically held an inferior position relative to other beneficial uses. If other uses degraded quality below recreation quality, the recreation user has usually been expected to seek alternative waters. This philosophy is being challenged with increased emphasis on the "enhancement of water quality." Water recreation uses are divided into two groups: primary contact recreation and secondary contact recreation. Secondary contact sports are those in which contact with water is either incidental or accidental, and the probability of ingesting appreciable quantities of water is minimal. Examples are boating, camping, and fishing. Primary contact recreation includes those activities in which there is prolonged and intimate contact with water involving considerable risk of ingesting quantities sufficient to pose a significant health hazard (10). Public health safety becomes the major concern for these, which include swimming, diving, water skiing, and surfing. Specific criteria for primary contact recreation use recommend that fecal coliform should be used as the indicator organism for evaluating the microbiological quality. The mean fecal coliform content should not exceed 200 per 100 ml, with not more than 10 percent of the total samples in a 30-day period exceeding 400 per 100 ml (10). These values are greater by a factor of 5 for secondary contact recreation use.

Animal wastes are the major agricultural source of bacteria normally considered as indices of sanitary quality. Using the membrane filter technique, median fecal coliform counts in storm-water runoff were estimated to be 72 million per 100 ml from a concrete feedlot and 18 million per 100 ml from a nonsurfaced feedlot (4) If such wastes were released to streams or other

waters, the quality for any contact recreation use would be seriously impaired. Excessive algae growth resulting from the presence of plant nutrients would likewise impair water quality for recreation use and aesthetic value. Other agricultural pollutants would have little or no effect on these uses except those already noted for fish, aquatic, and wildlife. One possible exception would be increased dissolved solids from irrigation return flow, if this resulted in a drastic change in pH. Primary contact recreation waters should have a pH value within the range of 6.5 to 8.3, and in no case should it be less than 5.0 nor more than 9.0 (10). The major effect of pH on the user is physiological, causing severe eye irritation and subsequent danger of infection.

Impact on Further Agricultural Use

Agricultural water supplies are used for domestic purposes, livestock watering, and irrigation of crops. That which is used at the farmstead must be suitable for human consumption. The same source may also be used in processing raw farm products and for cleaning milk handling equipment. The farmstead supply must be of excellent quality, since only a limited amount of treatment is possible. The Public Health Service Drinking Water Standards (11) are the accepted criteria for farmstead water use. This precludes the reuse of any agricultural waste waters for farmstead supplies.

Water supplied to livestock may not be limited by such strict criteria. It has been demonstrated that farm animals can tolerate much higher dissolved solids (salinity) concentrations than humans. The tolerance of animals to salt and other pollutants in water depends on many factors such as age, health, species, nature of diet, and type of salt. There also is evidence that animals can adjust to increased salinity within limits. Species differences in response to salinity concentrations have been developed in Australia and are listed in Table 3. These values should not be taken as absolute, but rather interpreted as indicative of the significant species variation that exists (10). Although these values indicate upper limits, ideally, livestock water should be of much better quality, and the ultimate desirable criteria should be no less than for man. A large percentage of grazing livestock obtain their water from surface sources. Irrigation tail water might be an acceptable source provided it is safe from a bacteriological and toxicity standpoint. Even though animals may utilize water which is contaminated with fecal organisms, their presence in large numbers is highly undesirable and should be avoided. It has also been shown that fish

Table 3. Proposed Safe Limits of Salinity for Livestock 1/

Animal	Threshold Salinity (mg/l)
Poultry	2,860
Swine	4,290
Horses	6,435
Dairy Cattle	7,150
Beef Cattle	10,000
Sheep (adult, dry)	12,000

1/From Ref. 10.

have lower tolerance limits for the agricultural biocides than livestock; therefore, the presence of fish in agricultural water supplies generally indicates its safety for livestock (10).

Irrigation of crops is the most likely reuse application of certain agricultural waste waters. Storm-water runoff from feedlots can be used to good advantage for this purpose. In addition to water utilization, plant nutrients and organic content contribute to plant growth and soil improvement. The major limitation of this reuse application is the control of application rate according to climate, soil characteristics, and plant cover to maintain acceptable infiltration rates and aerobic conditions (22). Land application of both solid and liquid animal wastes has considerable merit whether the objective is utilization or disposal. The practice decreases the hazard to adjacent surface waters and subsequent users, while at the same time those constituents that are pollutants in an aquatic environment may be at least partially utilized and degraded in the soil-plant environment.

In water-short areas, the capture and reuse of irrigation tail water (surface return flow) is being encouraged. This water is usually quite acceptable for irrigation reuse, especially if it is pumped back and mixed with the original supply. The major pollutant that would be increased by this practice is total dissolved solids. Whether or not it reaches intolerable levels would be determined by the salt level in the original supply and the salt tolerance of the crop being irrigated. More serious salt problems are encountered downstream from irrigated areas after the total return flow returns to the stream (5, 6, 7, 12).

The overall degradation of water quality and the presence of agricultural pollutants can adversely affect the quality requirements for irrigation use just as for other beneficial uses. In addition to total salinity, specific ion effects can be serious. The effects of arsenic, boron, and many of the heavy metals are documented in the literature (10) and need not be considered in detail here. The adverse effect of sodium on soil physical conditions is well known also. Suffice it to say that irrigation water quality should be evaluated for potential hazards to crops and soils whatever its source may be.

Agriculture's Responsibility

Water quality standards adopted by the States and approved by the Secretary of the Interior reflect the desires of the citizenry

for clean water. They serve as a policy statement on the uses for certain waters and the quality required to support those uses. We have looked at the impact of agricultural pollutants on the criteria for some of these uses; now let us take a look to the future and the implications for agriculture.

In addition to normal population growth, the trend is for a more rapid expansion of both economy and population in many of our western states (13). As expansion continues westward, greater demands are placed on water resources, and water quality becomes even more critical. As water use increases, water quality tends to decline. It is estimated (23) that planned and proposed water resource development in the upper Colorado River Basin will cause significant increases in salinity of the lower Colorado River where concentrations are already at critical levels for municipal, industrial, and agricultural use. Other western streams no doubt face similar problems. As agricultural development expands, pollutants from these sources likewise will increase.

Granted that much remains to be learned about the science and technology of the control of pollution from agricultural activities, the problems can be greatly alleviated if effective use is made of what is already known. Impoundment of wastes from feedlots followed by treatment and control measures presently available would do much to reduce the problem (22). Greater care and control in the proper and effective use of all types of agricultural biocides must be encouraged and practiced (19). Improved land and water management practices would do much to reduce soil erosion and nutrient losses from irrigated areas.

James Quigley, former Commissioner of FWPCA, stated (24): "Salt-laden return flows from irrigation systems admittedly constitute a difficult technical and engineering problem, but here too there is room for improvement in the overall management of many of our irrigation systems. Once it has been accepted that the problem must be dealt with, both the economics and technology will be worked out, just as they have been with many industrial wastes." Research dealing with farm water management and control seems to offer the most promise for salinity control from irrigated areas. Subsurface irrigation along with some means of controlling deep percolation losses is suggested as another profitable area for study. Little research to date has been directed at the control of pollutants in irrigation return flow. It has heretofore been accepted as an inevitable consequence of the practice. This viewpoint must now come under close scrutiny.

Recent Federal Water Pollution Control legislation provides funds for the support of worthy research projects related to the cause, control, and/or abatement of water pollution. These funds are administered by the Office of Research and Development of FWPCA and are available to public or private agencies, universities, research institutions, or individuals. The agricultural community can look to these resources for the support of research aimed at the treatment or control of agricultural pollutants. We can no longer expect our waterways to assimilate all of our untreated wastes. The demand for clean and usable water dictates that we build the cost of clean water into all of our operations. There are no alternatives, and the time is now.

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